Design of Fractal slot Antennas for WLAN and WiMAX Applications

A Thesis submitted in partial fulfillment of the requirements for the degree of

Bachelor of Technology

In

Electronics and Instrumentation Engineering

By

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And

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CERTIFICATE

This is to certify that the thesis entitled **“Design of Fractal slot Antenna for WLAN and WiMAX Applications”** was submitted by **JABLUN KERKETTA (108EI024) & SOUBHAGYA RANJAN BEHERA (108EI039)** in partial fulfillment of the requirements for the award of Bachelor of Technology Degree in **Electronics and Instrumentation Engineering** during session **2011-2012** at **National Institute of Technology, Rourkela**. A bonafide record of research work carried out by them under my supervision and guidance. The candidates have fulfilled all the prescribed requirements. The thesis which is based on candidates’ own work, have not submitted elsewhere for a degree or diploma. In my opinion, the thesis is of the standard required for the award of a bachelor of technology degree in Electronics and Instrumentation Engineering.

Place: Rourkela **(Prof. S.K Behera)**

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On the submission of my thesis entitled "**Design of Fractal slot Antennas for WLAN and WiMAX Applications**", I would like to extend my gratitude & my sincere thanks to my supervisor **Prof. S.K Behera**, Department of Electronics and Communication Engineering, for his constant motivation and support during the course of my work in the last one year. I truly appreciate and value his esteemed guidance and encouragement from the beginning to the end of this thesis. His knowledge and guidance at the time of crisis would be remembered lifelong. I am very thankful to **Sir Yogesh Choukiker** for his valuable suggestions and comments during this project period.

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JABLUN KERKETTA

SOUBHAGYA RANJAN BEHERA

ABSTRACT

A wideband printed slot antenna suitable for wireless local area network (WLAN) and satisfying the worldwide interoperability for microwave access (WiMAX) applications is proposed here. The antenna is microstrip line fed and its structure is based on fractal geometry where the resonance frequency of antenna is lowered by applying iteration techniques. The Project aims in finding the return loss and the radiation pattern. Analysis of fractal antenna is done by using Software named CST Microwave Studio Suite. The antenna size inclusive of the ground plane is compact and has a wide operating bandwidth. The antenna exhibits omnidirectional direction radiation coverage with a gain better than 2.0 dBi in the entire operating band. Fractals shapes and their properties are discussed. Hence it is important to analyze them.

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CHAPTER 1

INTRODUCTION

1.1 **PROJECT BACKGROUND**

In modern wireless communication systems and increasing of other wireless applications, wider bandwidth, multiband [7-8] and low profile antennas are in great demand for both commercial and military applications. This has initiated antenna research in various directions; one of them is using fractal shaped antenna elements. [9] Traditionally, each antenna operates at a single or dual frequency bands[7-8], where different antenna is needed for different applications. This will cause a limited space and place problem. In order to overcome this problem, multiband antenna can be used where a single antenna can operate at many frequency bands. One technique to construct a multiband antenna is by applying fractal shape into antenna geometry [9]. This project presents the Koch and Sierpinski Gasket patch antenna [3-4][10] where this famous shape, the antenna behaviors are investigated. In addition to the theoretical design procedure, numerical simulation was performed using software (CST) [11] to obtain design parameters such as size of patch and feeding location. The antennas have been analyzed and designed by using the software CST Microwave Studio Suite [11].

1.2 **OBJECTIVE**

The objective of this project is to design and simulate the Koch and Gasket patch (microstrip) monopole fractal antenna [9-10]. The behavior and properties of these antennas are investigated.

1.3 SCOPE OF THE PROJECT

The scopes defined for this project are as follows:

- Understanding the antenna concept.
- Perform numerical solutions using CST Microwave Studio software
- Study of the antenna properties.
- Comparison of measurement and simulation results.

1.4 THESIS ORGANIZATION

Chapter 1: In the first chapter basic overview of the project done is provided. This chapter describes the need for microstrip antennas. Use of fractals in MA design is of a great use. A brief history of the antenna is provided here.

Chapter 2: This chapter describes various antenna properties and terms associated with it. Basic feeding techniques are well described. A small discussion is done on the advantages and disadvantages of various types of feeding methods.

Chapter 3: This chapter describes how the use of fractal geometry in MA design had been of a great use. Some efficient fractal geometries are described in this chapter.

Chapter 4: This chapter includes the design process and simulation results of Koch Fractal Slot antenna with CPW (Coplanar waveguide) feed. The results showing various properties of fractal antenna are also provided.

Chapter 5: This chapter includes the design process and simulation results of Sierpinski Carpet antenna with CPW feed. The results showing various properties of fractal antenna are also provided.

CHAPTER 2

ANTENNA THEORY

2.1 **INTRODUCTION**

Microstrip antenna [1-2] [12] is a simple antenna that consists of radiated patch component, dielectric substrate, and ground plane. The radiated patch and ground plane is a thin layer of copper or gold which is a good conductor. Each dielectric substrate has their own dielectric permittivity values. This permittivity will influence the size of the Antenna. Microstrip antenna is a low profile antenna. They have several advantages like light weight, small dimension, cheap and easy to integrate with other circuits which make it chosen in many applications.

2.2 **ANTENNA PROPERTIES**

The performance of the antenna is determined by several factors. Properties of those factors are as follows:

Input Impedance

Generally, input impedance is important to determine maximum power transfer between transmission line and the antenna. This transfer only happen when input impedance of antenna and input impedance of the transmission line matches. If they do not match, reflected wave will be generated at the antenna terminal and travel back towards the energy source. This reflection of energy results causes a reduction in the overall system efficiency.

Gain

The gain of an antenna is essentially a measure of the antenna's overall efficiency. If an antenna is 100% efficient, it would have a gain equal to its directivity. There are many factors that affect and reduce at the overall efficiency of an antenna. Some of the most significant factors that impact antenna gain include impedance matching, network losses, material losses and random losses. By considering all factors, it would appear that the antenna must overcome a lot of adversity in order to achieve acceptable gain performance.

Radiation Pattern

The radiation patterns of an antenna provide the information that describes how the antenna directs the energy it radiates. All antennas if 100% efficient, will radiate the same total energy for equal input power regardless of the pattern shape. Radiation patterns are generally presented on a relative power dB scale.

Directivity

Directivity, D is important parameter that shows the ability of the antenna focusing radiated energy. Directivity is the ratio of maximum radiated to radiate reference antenna. Reference antenna usually is an isotropic radiator where the radiated energy is same in all direction and has directivity of 1. Directivity is defined as the following equation:

$$\mathbf{D = F_{max} / F_0}$$

Where, F_{max} = Maximum radiated energy

F_0 = Isotropic radiator radiated energy

Polarization

The polarization of an antenna describes the orientation and sense of the radiated wave's electric field vector. There are three types of basic polarization:

- Linear polarization
- Elliptical polarization
- Circular polarization

Generally most antennas radiate with linear or circular polarization. Antennas with linear polarization radiate at the same plane with the direction of the wave propagate. For circular polarization the antenna radiate in circular form.

Bandwidth

The term bandwidth simply defines the frequency range over which an antenna meets a certain set of specification performance criteria. The important issue to consider regarding bandwidth is the performance tradeoffs between all of its performance properties described above. There are two methods for computing an antenna bandwidth.

An antenna is considered broadband if $f_H/f_L \geq 2$.

Narrowband by % age

$BW_p = (\mathbf{f_h}-\mathbf{f_l})/\mathbf{f_0} \times 100\%$

Broadband by ratio

$BW_b = \mathbf{f_h}/\mathbf{f_l}$

where f_0 = Operating frequency

f_h = Higher cut-off frequency

f_l = Lower cut-off frequency

2.3 BASIC MICROSTRIP ANTENNA

The first idea to use microstrip [12] antenna started since the beginning of 1950's and design concept was introduced by Deschamps. Several years later, Gutton and Baissinot had s patent of the basic microstrip antenna. It was first published in 1952 by Grieg and Englemann. Figure below shows the basic structure of microstrip antenna which consists of radiating patch, dielectric substrates and ground plane. Bottom layer of dielectric substrate is fully covered by conductors that act as a ground plane. The thickness of substrates layer can increase the bandwidth and efficiency, but unfortunately it will generate surface wave with low propagation that cause loss of power.

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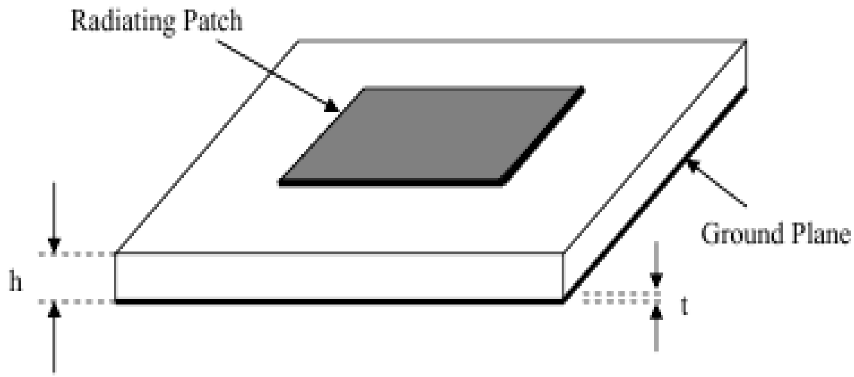


Figure 2.1: Parts of a Microstrip Antenna

In the figure, **h**= substrates thickness; **t**= conductor thickness.

When a microstrip antenna is connected to a microwave source, it is energized. The charge distribution will establish on the upper and lower surfaces of the patch, as well as on the surface on the ground plane. The positive and negative charge distribution then arises.

Microstrip antennas have got high intention because of their good characteristics like:

• Low profile

• Light weight

• Cheap

• Easy to integrate with other circuits

• Used widely in many applications (both in commercial and military)

However there are several disadvantages of using microstrip antennas:

• Narrow bandwidth

• Low gain

• Surface wave excitation

• Low efficiency

• Low power handling capacity

2.4 FEEDING TECHNIQUES

Feeding techniques [1-2-13] are important in designing the antenna to make antenna structure so that it can operate at full power of transmission. Designing the feeding techniques for high frequency, need more difficult process. This is because the input loss of feeding increases depending on frequency and finally give huge effect on overall design. There are a few techniques that can be used.

1 Microstrip Line feeding
2 Coaxial Probe feeding
3 Aperture Coupled feeding
4 Proximate Coupled feeding
5 CPW feeding

Microstrip Line feeding

It has more substrate thickness i.e. directly proprtional to the surface wave.

Radiation bandwidth limit is 2-5%.It is easy to fabricate and model. Microstrip line feed is one of the easier methods to fabricate as it is a just conducting strip connecting to the patch and therefore can be consider as extension of patch. It is simple to model and easy to match by controlling the inset position. However the disadvantage of this method is that as substrate thickness increases, surface wave and spurious feed radiation increases which limit the bandwidth.

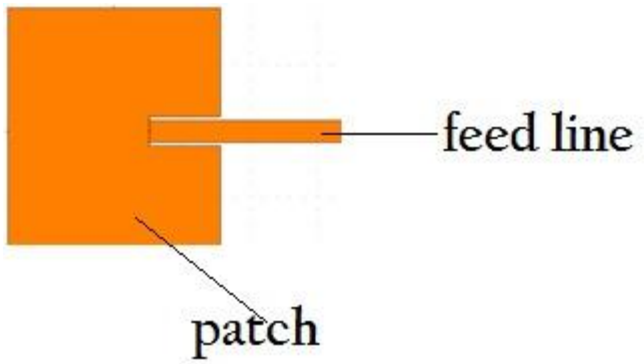


Figure 2.2: Microstrip line feeding

Coaxial Probe feeding

It has low spurious radiation and narrow bandwidth.It is easy to fabricate but difficult to model. Coaxial feeding is feeding method in which that the inner conductor of the coaxial is attached to the radiation patch of the antenna while the outer conductor is connected to the ground plane.

Advantages

- Easy of fabrication
- Easy to match
- Low spurious radiation

Disadvantages

- Narrow bandwidth
- Difficult to model specially for thick substrate
- Possess inherent asymmetries which generate higher order modes which produce cross-polarization radiation.

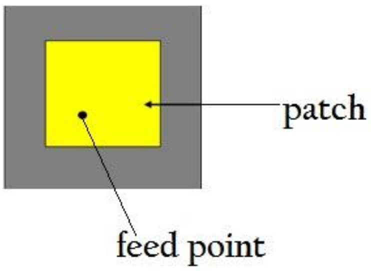


Figure 2.3: Coaxial Probe feeding

Aperture Coupled feeding

It has narrow bandwidth and moderate spurious radiation. Aperture coupling consist of two different substrate separated by a ground plane. On the bottom side of lower substrate there is a microstrip feed line whose energy is coupled to the patch through a slot on the ground plane separating two substrates. This arrangement allows independent optimization of the feed mechanism and the radiating element. Normally top substrate uses a thick low dielectric constant substrate while for the bottom substrate; it is the high dielectric substrate. The ground plane, which is in the middle, isolates the feed from radiation element and minimizes interference of spurious radiation for pattern formation and polarization purity.

Advantages

Allows independent optimization of feed mechanism element.

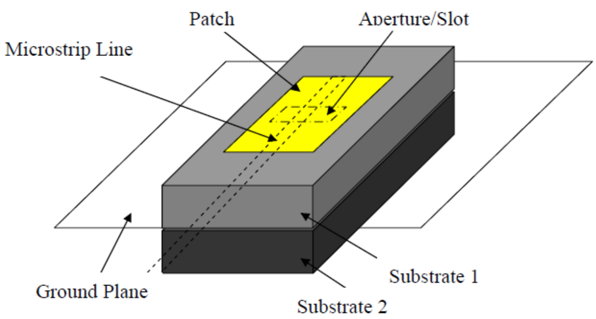


Figure 2.4: Aperture couple feeding

Proximate Coupled feeding

Proximity coupling has the largest bandwidth, has low spurious radiation. However fabrication is difficult. Length of feeding stub and width-to-length ratio of patch is used to control the match.

Advantage

- It has largest band width.
- It is easy to model.
- It has low spurious radiation and is difficult to fabricate.

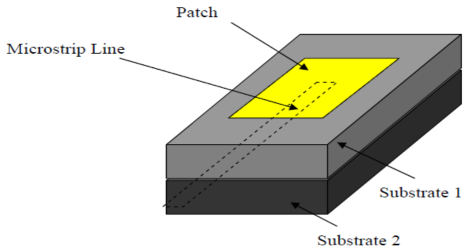


Figure 2.5: Proximated couple feeding

CPW feeding

A coplanar waveguide structure consists of a median metallic strip of deposited on the surface of a dielectric substrate slab with two narrow slits ground electrodes running adjacent and parallel to the strip on the same surface. This transmission line is uniplanar in construction, which implies that all of the conductors are on the same side of the substrate.

They have many features such as low radiation loss, less dispersion, easy integrated circuits and simple configuration with single metallic layer, and no via holes required. The CPW fed antennas have recently become more and more attractive because of its some more attractive features such as wider bandwidth, better impedance matching, and easy integration with active devices or monolithic microwave integrated circuits. Etching the slot and the feed line on the same side of the substrate eliminates the alignment problem needed in other wideband feeding techniques such as aperture coupled and proximity feed.

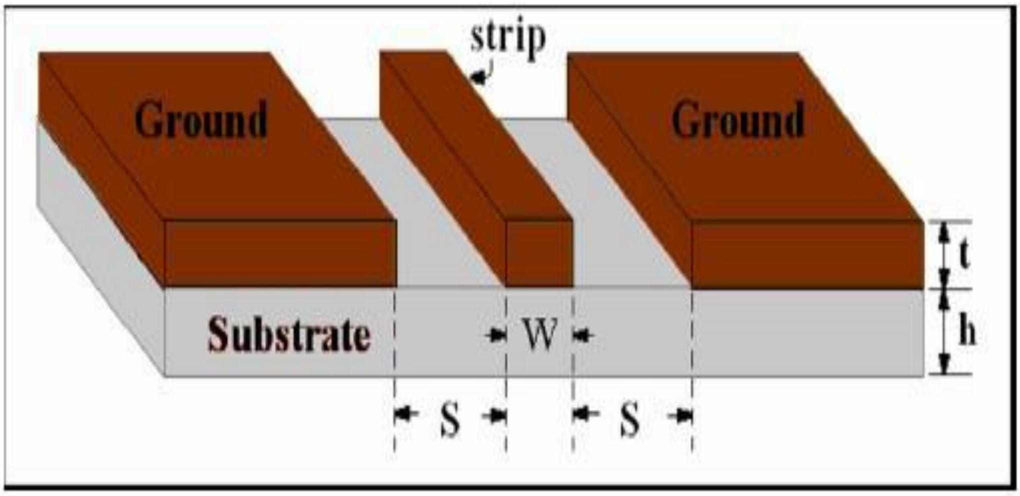


Figure 2.6: Structure of coplanar waveguide feed

CHAPTER 3

FRACTAL ANTENNA

3.1 **FRACTAL THEORY**

In modern wireless communication systems wider bandwidth, multiband and low profile antennas are in great demand for both commercial and military applications. This has initiated antenna research in various directions; one of them is using fractal shaped antenna elements. Traditionally, each antenna operates at a single or dual frequency bands, where different antennas are needed for different applications.

Fractal shaped antennas have already been proved to have some unique characteristics that are linked to the various geometry and properties of fractals. Fractals were first defined by Benoit Mandelbrot in 1975 as a way of classifying structures whose dimensions were not whole numbers. Fractal geometry has unique geometrical features occurring in nature. It can be used to describe the branching of tree leaves and plants, rough terrain, jaggedness of coastline, and many more examples in nature. Fractals have been applied in various field like image compression, analysis of high altitude lightning phenomena, and rapid studies are apply to creating new type of antennas.. Fractals are geometric forms that can be found in nature, being obtained after millions of years of evolution, selection and optimization.

Fractal Antennas Elements

There are many benefits when we applied these fractals to develop various antenna elements. By applying fractals to antenna elements:

- We can create smaller antenna size.
- Achieve resonance frequencies that are multiband.
- May be optimized for gain.
- Achieve wideband frequency band.

Most fractals have infinite complexity and detail that can be used to reduce antenna size and develop low profile antennas. For most fractals, self-similarity concept can achieve multiple frequency bands because of different parts of the antenna are similar to each other at different scales. The combination of infinite complexity and self similarity makes it possible to design antennas with various wideband performances.

We need fractal antenna due to the following facts:

- Very broadband and multiband frequency response that derives from the inherent properties of the fractal geometry of the antenna.
- Compact size compared to antennas of conventional designs, while maintaining good to excellent efficiencies and gains.
- Mechanical simplicity and robustness; the characteristics of the fractal antenna are obtained due to its geometry and not by the addition of discrete components.
- Design to particular multi frequency characteristics containing specified stop bands as well as specific multiple pass bands.

3.2 **FRACTAL GEOMETRY**.

There are many fractal geometries [1] that have been found to be useful in developing new and innovative design for antennas. Figure below shows some of these unique geometries.

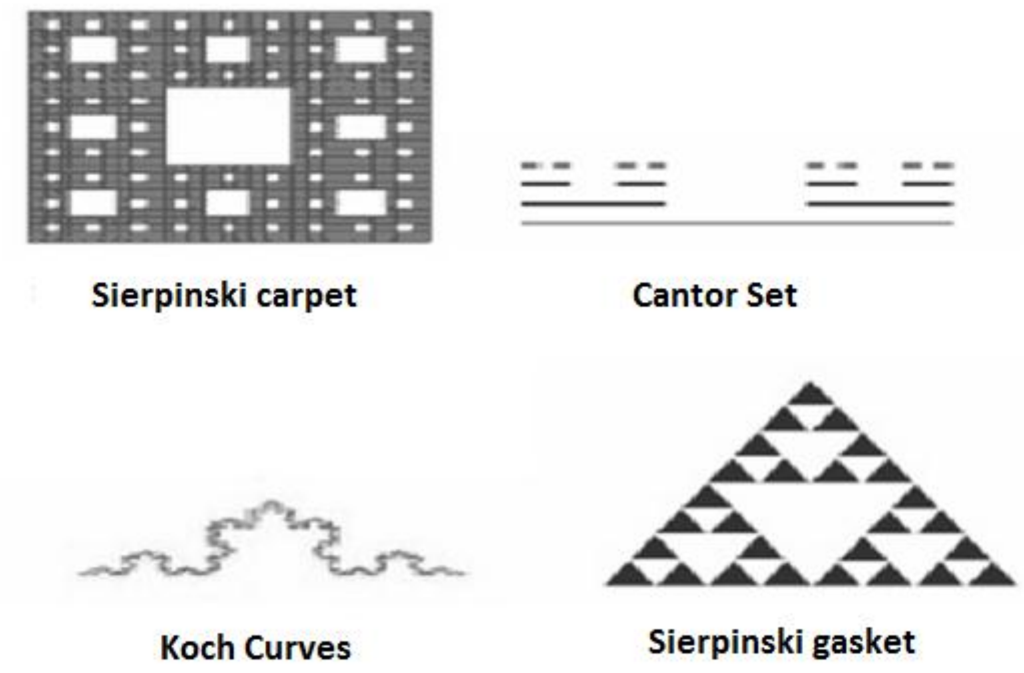


Figure 3.1: Types of fractal geometries

Sierpinski Gasket Geometry

Sierpinski gasket geometry [1]is the most widely studied fractal geometry for antenna applications. The steps for constructing this fractal are described.1st a triangle is taken in a plane. Then in next step a central triangle is removed with vertices that are located at the midpoint of the sides of the triangle as shown in the figure. The process is then repeated for remaining triangles as shown in figure. The Sierpinski gasket fractal is formed by doing this iterative process infinite number of times. Black triangular areas represent a metallic conductor and the white triangular areas represent the region from where metals are removed

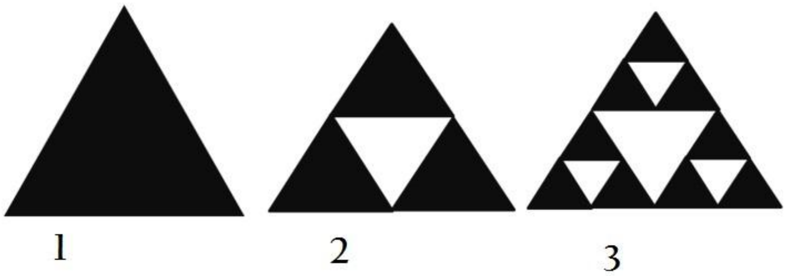


Figure 3.2: Steps of construction for Gasket geometry

Sierpinski Carpet

The Sierpinski carpet [1] is constructed similar to the Sierpinski gasket, but it use squares instead of triangles. In order to start this type of fractal antenna, it begins with a square in the plane, and then divides it into nine smaller congruent squares where the open central square is dropped. The remaining eight squares are divided into nine smaller congruent squ

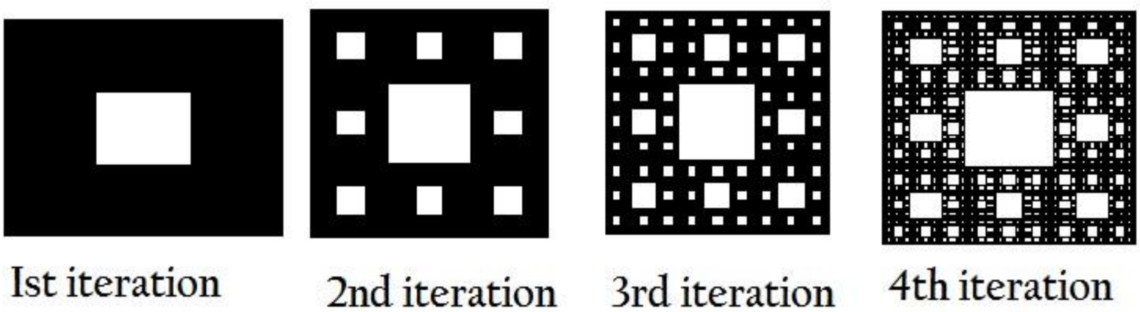


Figure 3.3: Steps of Iteration to get Carpet geometry

Koch Curves

The geometric construction of the standard Koch curve[1] is fairly simple. It starts with a straight line as an initiator. This is partitioned into three equal parts, and the segment at the middle is replaced with two others of the same length. This is the first iterated version of the geometry and is called the generator. The process is reused in the generation of higher iterations.

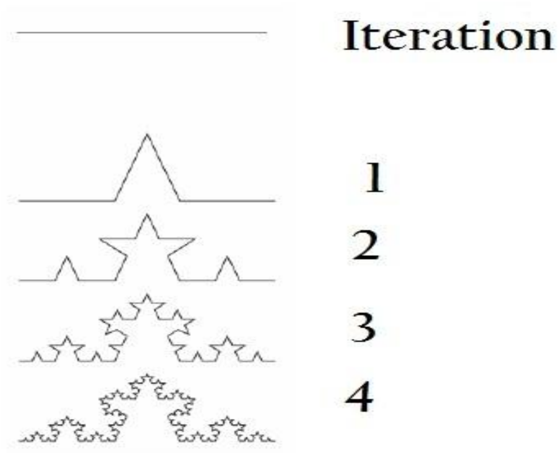


Figure 3.4: Steps of construction for Koch curve geometry

The Cantor Set Geometry

The Cantor Set [1] is created by the following algorithm. It starts with the closed interval [0, 1].

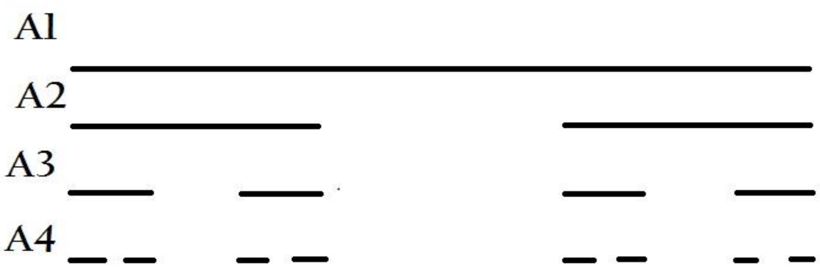


Figure 3.5: Steps for the Cantor Set geometry

Say it as set A1 or the 0th (initial) set. Delete the middle open third. This leaves a new set, called A2 [0,1/3] U [2/3,1]. Each iteration through the algorithm removes the open middle third from each segment of the previous iteration. Thus, the next two sets would be A3[0,1/9]U[2/9,1/3]U[2/3,7/9]U[8/9,1] and according to the previous one A4 set will be A4 [0,1/27]U[2/27,1/9]U[2/9,7/27]U

[8/27,1/3]U[2/3,19/27]U[20/27,7/9]U[8/9,25/27]U[26/27,1]. We can see that the set becomes sparser as the number of iteration increases. The Cantor Set is defined to be the set of the points that remain as the number of iterations tends to infinity.

CHAPTER 4

CPW-FED KOCH FRACTAL SLOT ANTENNA

4.1 **THEORY**

Since there is a rapid development in wireless communication systems their applications are increasing every day. The ultra wideband antenna has become an important factor in developing the Ultra wideband technique. Accordingly antennas are designed to radiate in a relatively narrow range of frequencies. As opposed to traditional narrowband antennas, the UWB antennas can transmit and receive electromagnetic waves in a wide range. The Ultra wide antennas are used to transmit the signal with minimum noise and distortion in the shape of the pulses. Much important is that the increasing demand for low profile and portable miniature wireless systems has increased interests in the compact antennas .As an significant member of the Ultra wideband family, the slot antenna has the advantages of wideband, and the cost is low benefits are there. It can be integrated with many electronics devices, chips, mobile phones etc. There are more advantages of low radiation loss, and dispersion. The structure of coplanar-waveguide- (CPW-) fed printed slot antennas is very simple consisting of a single metallic layer. It can be easily integrated with microwave integrated circuits.

In this CPW-fed slot antenna the bandwidth is increased. Koch fractal geometry is applied in this antenna. WLANs (Wireless Local Area Networks) are proposed to operate in the 2.4 GHz frequency bands (2.4 - 2.48 GHz) and 5 GHz frequency bands (5.15–5.35 GHz). WiMAX (Worldwide Interoperability for Microwave Access) is designed to operate in the range 2.5 - 2.69/3.4 - 3.69/5.25 - 5.85 GHz bands. Since this range of frequencies can be used simultaneously in many systems, we need a single antenna that covers all these ranges. The minimum resonance of the wide slot antenna depends on the slot boundary .The concept of space filling of the Koch curves used in the design of miniature and multi-band patch antennas can also be applied for wide-slot antennas.

Here we use a CPW-fed modified Koch Snowflake slot antenna operating over a wide frequency band, covering the 2.4/5.2/5.8 GHz range for WLAN and 2.5/3.5/4.5 GHz range for WiMAX . The definitions for some terms used to describe the simulated result are provided below.

S-Parameter

- S-parameters describe the input-output relationship between terminals (or ports) in a circuit system.
- It represents the power reflected or radiated by the antenna.
- It is a measure of the accepted power by the antenna.

Smith Chart

- The Smith Chart is used for visualizing the impedance of a transmission line and antenna system as a function of frequency.
- It is extremely helpful for impedance matching.
- Smith Chart is a graphical method of displaying the impedance of an antenna, which can be a single point or a range of points to display the impedance as a function of frequency.

Far field

- Far field determines antenna's radiation pattern.
- The far field is the region far from the antenna where the radiation pattern does not change shape with distance.
- This region is dominated by radiated fields, with the E- and H-fields orthogonal to each other.

Gain

- Antenna Gain describes the amount of power transmitted in the direction of peak radiation to that of an isotropic source.
- Antenna gain accounts for the actual losses that occur.

4.2 PROPOSED ANTENNA DESIGN

The proposed model is designed using three iterative steps. Here the same radiating patch is used throughout the steps. But, the ground plane shape is modified in the consecutive steps. Starting from a triangle and superimposing another similar inverted triangle upon it and so on we have obtained the required geometry.

Koch Snowflake geometry in its different iteration stages are depicted below.

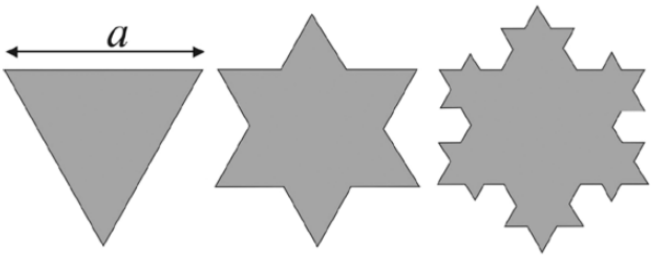


Fig 4.1 1st 2nd and 3rd iteration

1st Iteration

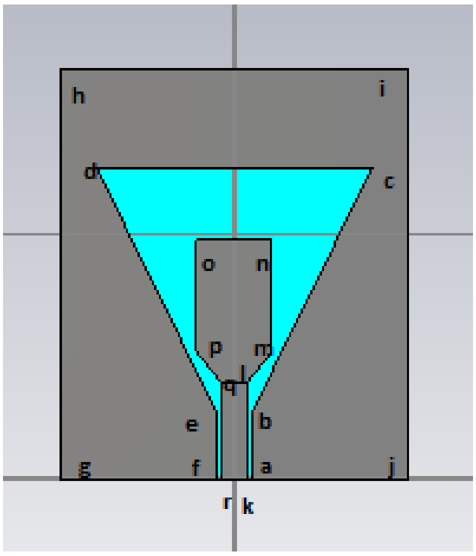
The coordinates of the geometry of the designed slot antenna are listed below.

Point	x	y	Point	x	y	Point	x	y
a	1.45	0	g	-14.25	0	m	3.1	10.5
b	1.45	5.5	h	-14.25	33.5	n	3.1	19.6
c	11.25	25.5	i	14.25	33.5	o	-3.1	19.6
d	-11.25	25.5	j	14.25	0	p	-3.1	10.5

e	-1.45	5.5	k	1.1	0	q	-1.1	8
f	-1.45	0	l	1.1	8	r	-1.1	8

According to the given table the various parts of the antenna were designed and the model was simulated. The pictorial representation of designed model and the return loss from the simulated results are given below.

Geometry



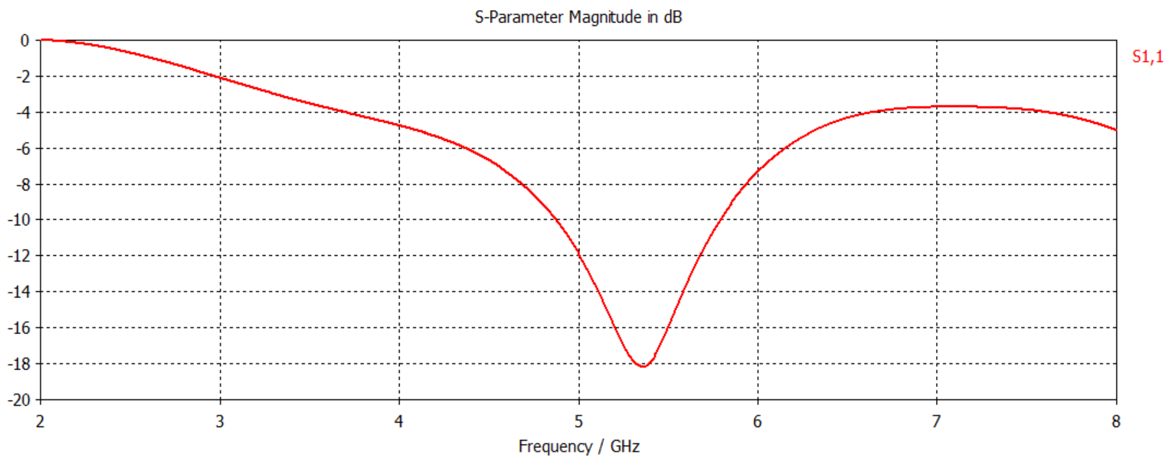


Fig 4.2 1st iteration return loss

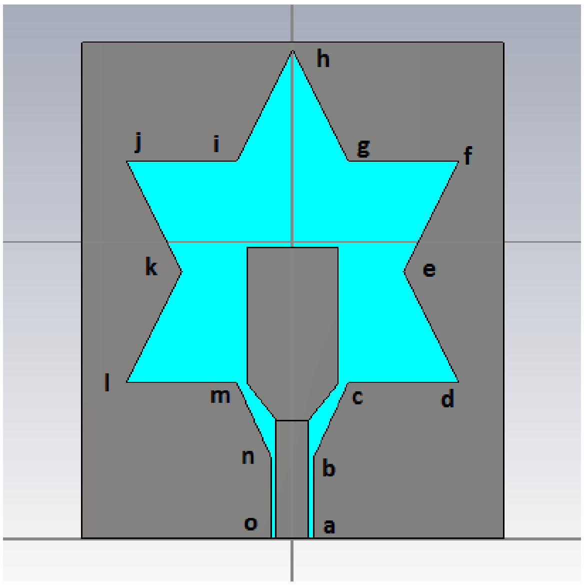
2nd Iteration

The coordinates of the geometry of the designed slot antenna are listed below.

Point	x	y	Point	x	y	Point	x	y
a	1.45	0	f	11.25	25.5	k	-7.5	18
b	1.45	5.5	g	3.75	25.5	l	-11.25	10.5
c	3.75	10.5	h	0	33	m	-3.75	10.5
d	11.25	10.5	i	-3.75	25.5	n	-1.45	5.5
e	7.5	18	j	-11.25	25.5	o	1.45	0

According to the given table the various parts of the antenna were designed and the model was simulated. The pictorial representation of designed model and the return loss from the simulated results are given below

Geometry



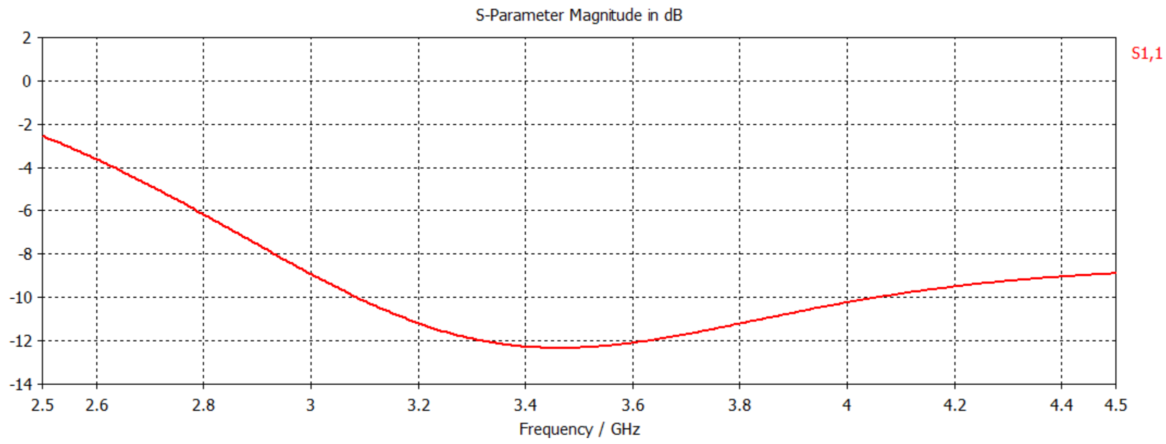


Fig 4.3 2nd iteration return loss

3rd Iteration

The coordinates of the geometry of the designed slot antenna are listed below.

Table 4.1: Dimensions for Koch Fractal Antenna Model

Parameter	Value	Parameter	Value
h	1.6 mm	S	2.2 mm
a	26 mm	s_1	2.5 mm
L	33.5 mm	s_2	2.5 mm
W	28.5 mm	s_3	9.1 mm
L_f	5.5 mm	s_w	6.2 mm
d	0.35 mm	$€_r$	4.4

Koch Fractal Antenna Model

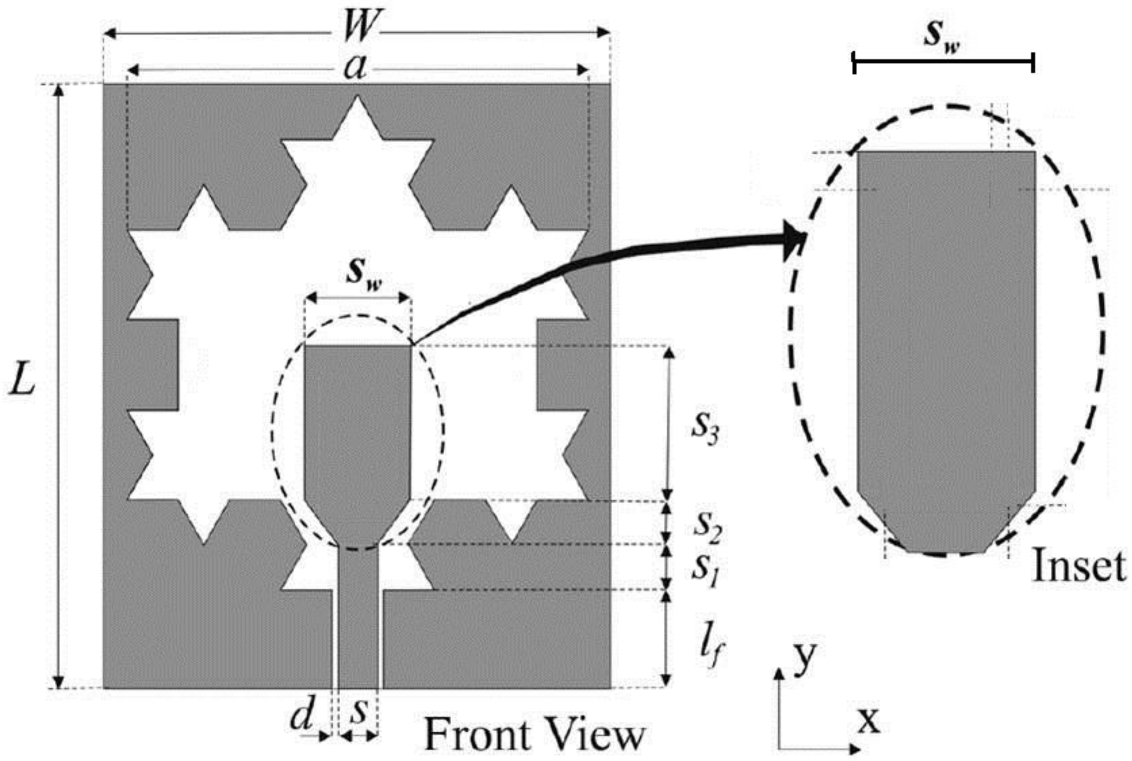


Figure 4.4: Geometry of Koch Fractal Antenna

The above model provided with the dimensions was designed using CST Microwave Studio. [11] The views from different angles are depicted below.

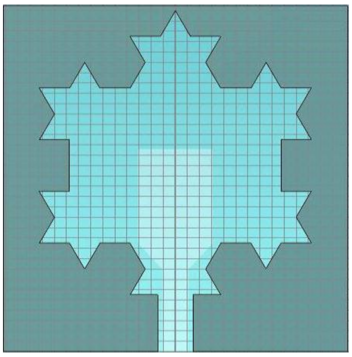


Figure 4.5(a): Ground Plane

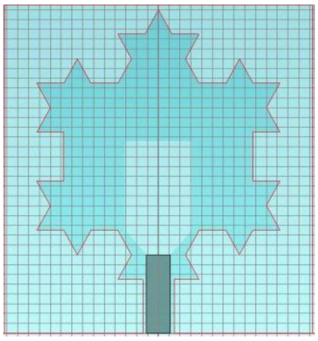


Figure 4.5(b): Feed Line

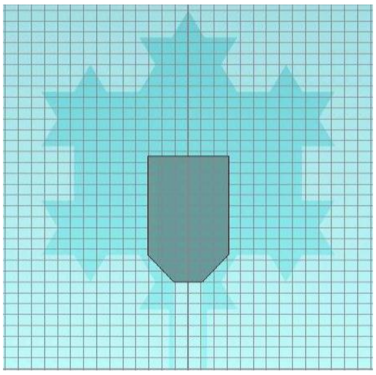


Figure 4.5(c): Radiating Patch

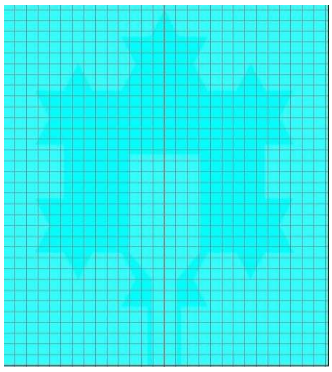


Figure 4.5(d): Substrate (Backside view)

The various parts of the Koch antenna were modeled and the respective materials were chosen. Permittivity of the substrate was taken as 4.4. All the parts were connected to a common port. Then the desired frequency of operation was chosen. After that the model was simulated to find the return loss. Following the return loss the Smith chart was plotted. Then the far field patterns at various frequencies were obtained using the CST tools. From those far field values the gain was calculated.

Return Loss

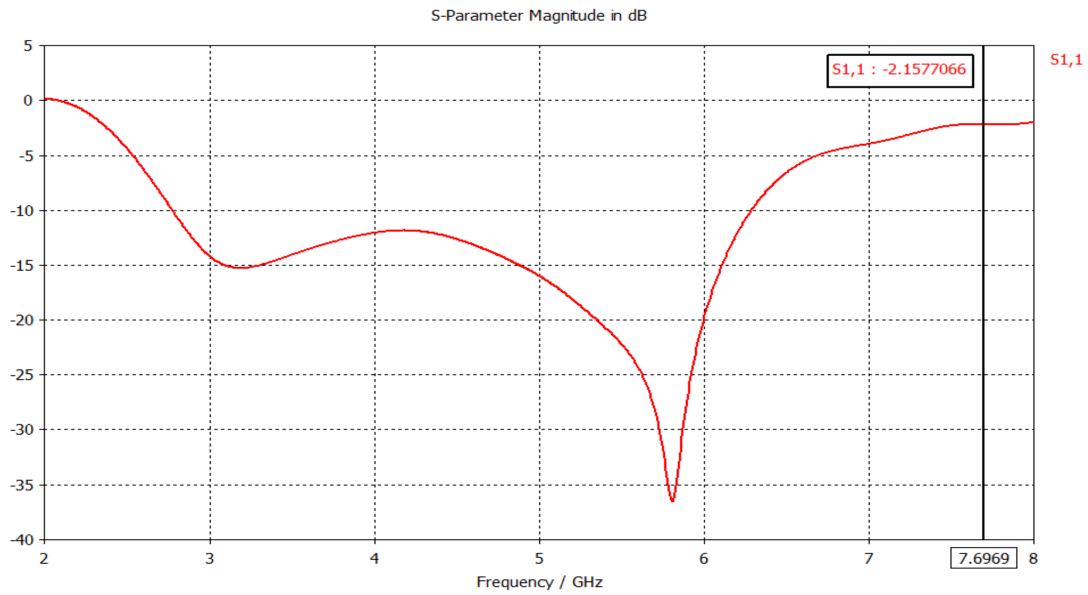


Figure 4.6: Return loss plot for Koch Antenna

Smith Chart

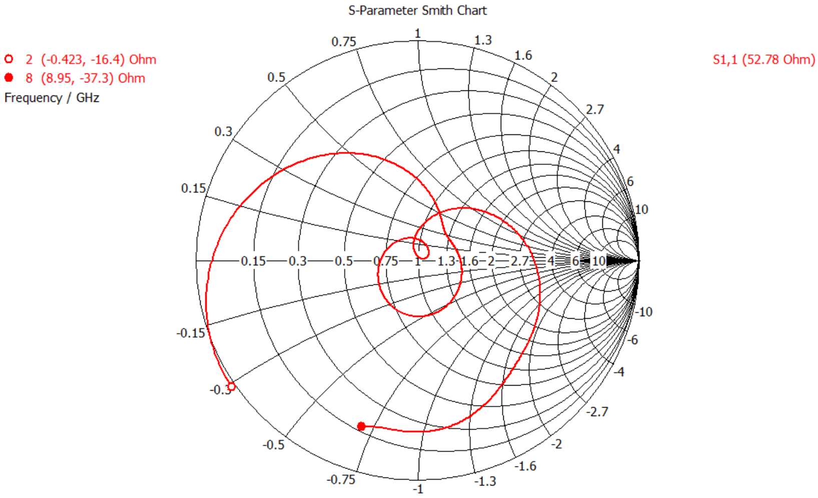
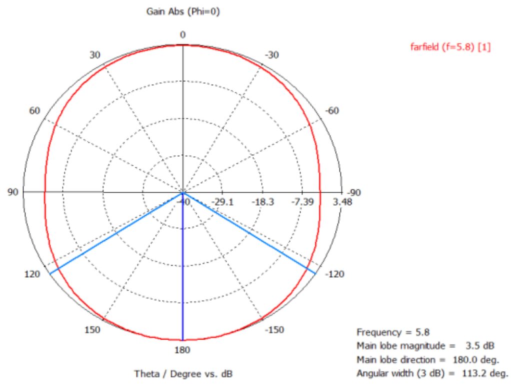
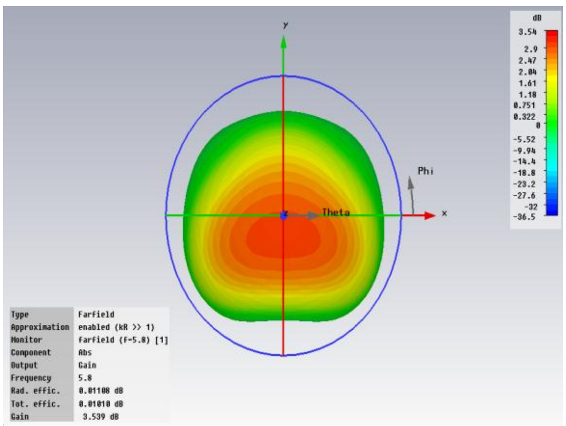


Figure 4.7: Smith Chart plot for Koch Antenna

Far field plot at peak (f = 5.8 GHz)



(a)Polar plot



(b): 3d Plot

Figure 4.8: Far field plots for Koch Antenna

Gain plot for Koch Antenna

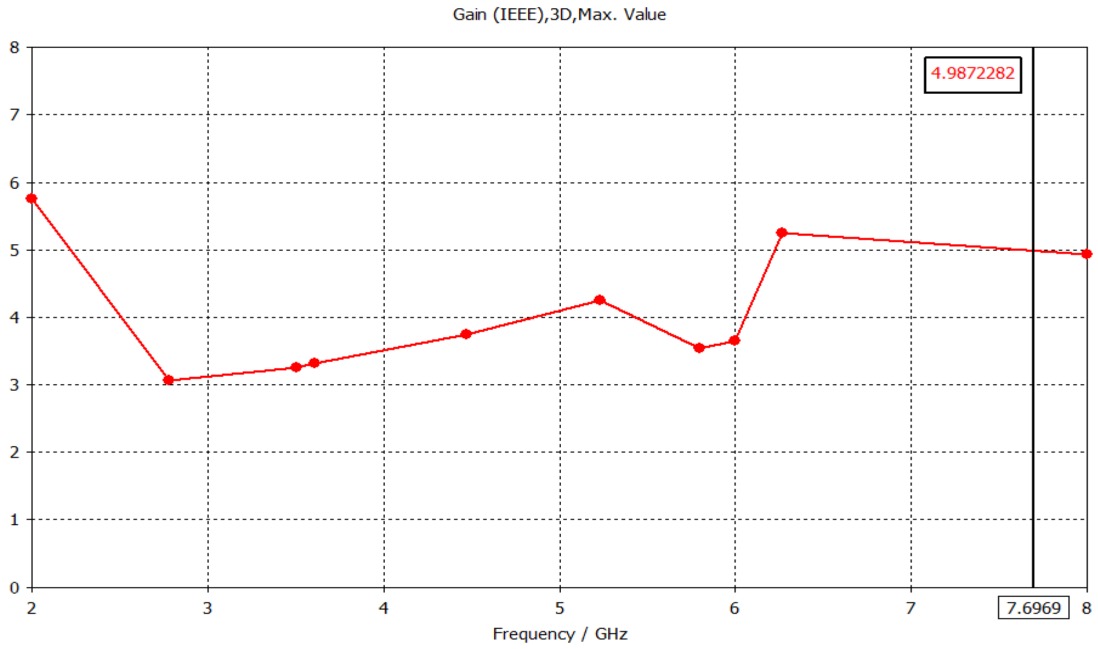


Figure 4.9: Gain plot for Koch Antenna

CHAPTER 5

SIERPINSKI CARPET ANTENNA WITH CPW FEED

5.1 THEORY

The increase of wireless technology has motivated the designers to make new antenna design that can cover wide range of frequencies and can be useful for multipurpose. Due to the low cost, low profile and complex configuration it has gained interest for its application. Here we have designed an antenna that will be useful for WLAN application. Fractal geometry is used for designing antenna that has been successfully applied to get wide range of bandwidth. Here, for designing of this antenna we use Sierpinski Carpet fractal geometry. A dual band WLAN antenna using a Sierpinski carpet fractal geometry in a planar monopole configuration is designed which covers the multiband characteristics of fractals and also the simplicity of monopole antenna.

5.2 PROPOSED ANTENNA DESIGN

Here in Sierpinski Carpet antenna we have made the ground plane geometry fixed and varied the radiating patch structure. Modifications are done in the patch structure to obtain different radiation pattern. The bandwidth of the antenna is enhanced by using different patch structures. Those structures are provided below.

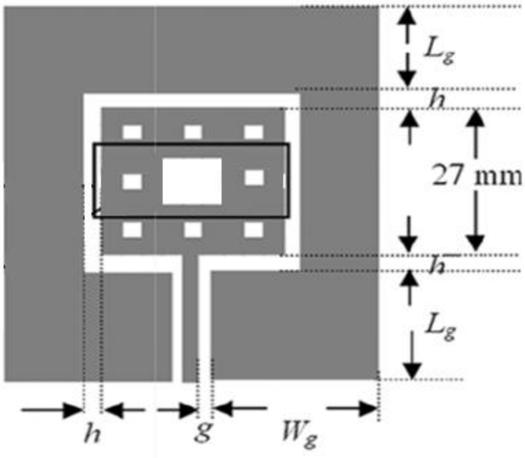
Design I

The proposed dual band antenna has substrate thickness 1.59 mm, permittivity $€_r$ = 3.2. The smallest squares have dimension 3mm x 3mm.

Parameter	Value	Parameter	Value
W_g	20.5 mm	h	1.743 mm
L_g	18.4	g	1 mm
L_s (L_{g+} h)	20.143	L_w	1.5 mm

The diagram of model and the return loss for the particular patch shape is derived from the simulated results and are given below.

Design I



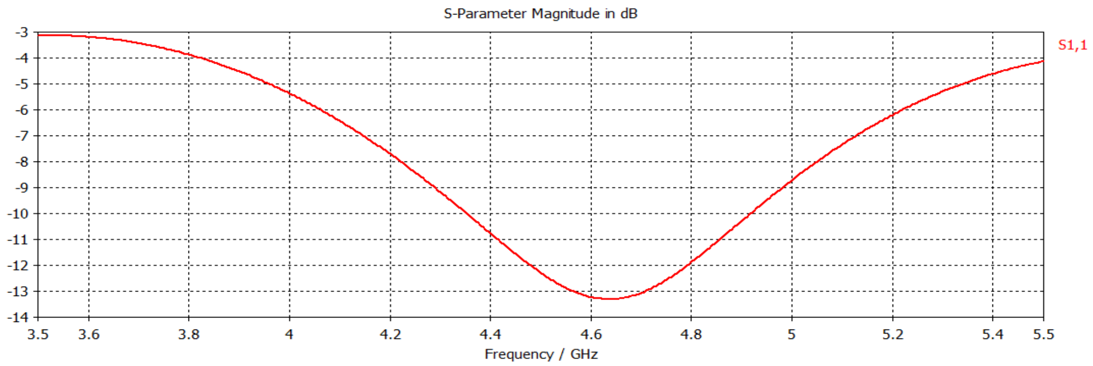
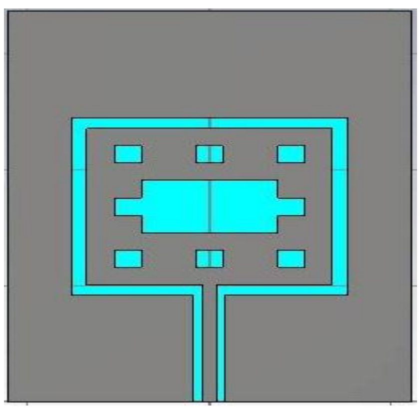


Figure 5.1: Return loss plot for Sierpinski carpet Antenna

Design II



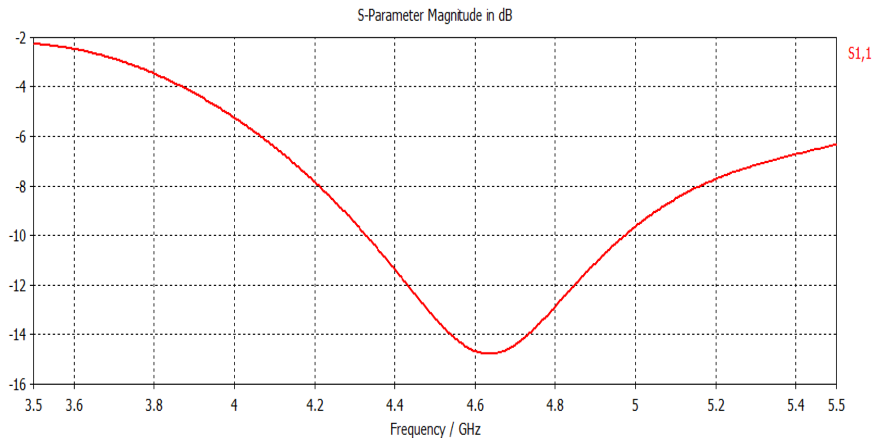
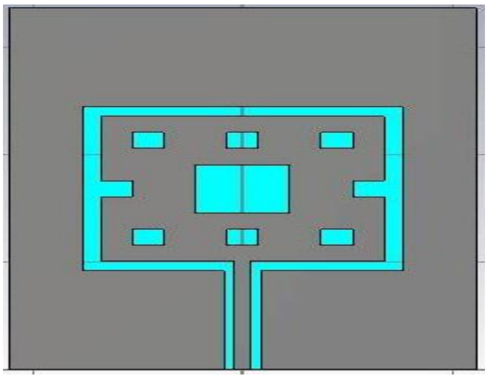


Figure 5.2: Return loss plot for Sierpinski carpet Antenna

Design III



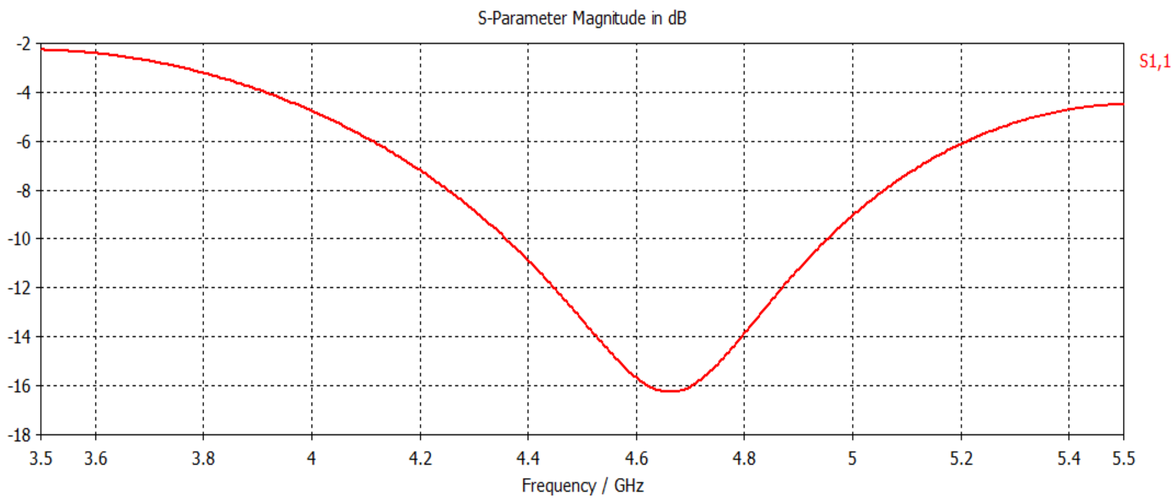
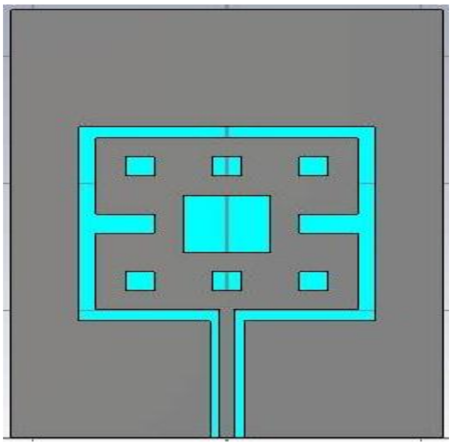


Figure 5.3: Return loss for Sierpinski carpet Antenna

Design IV



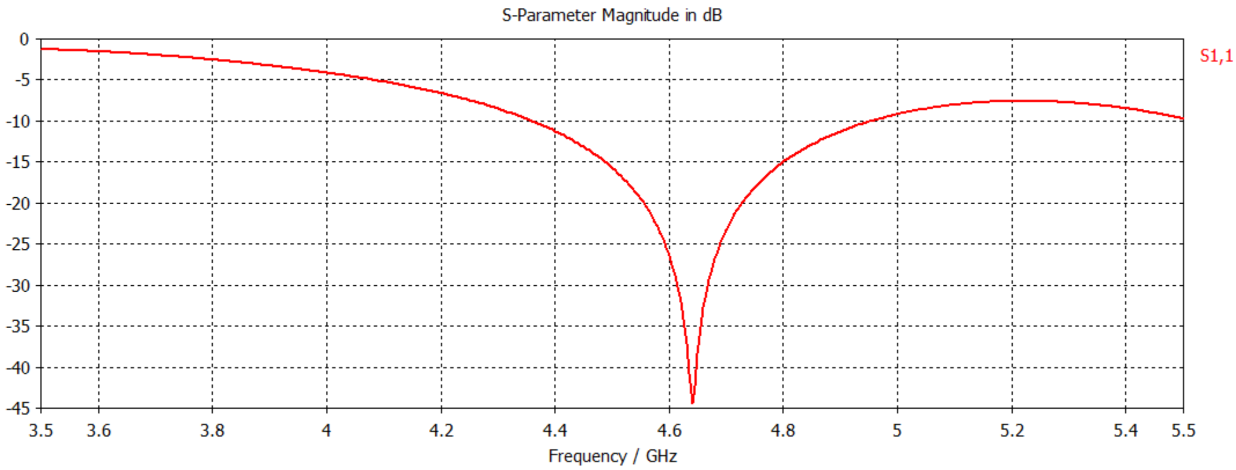
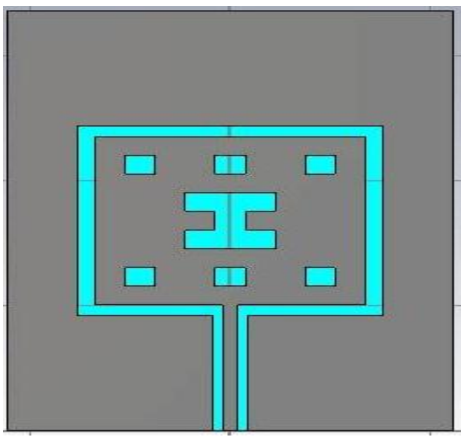


Figure 5.4: Return loss for Sierpinski carpet Antenna

Design V



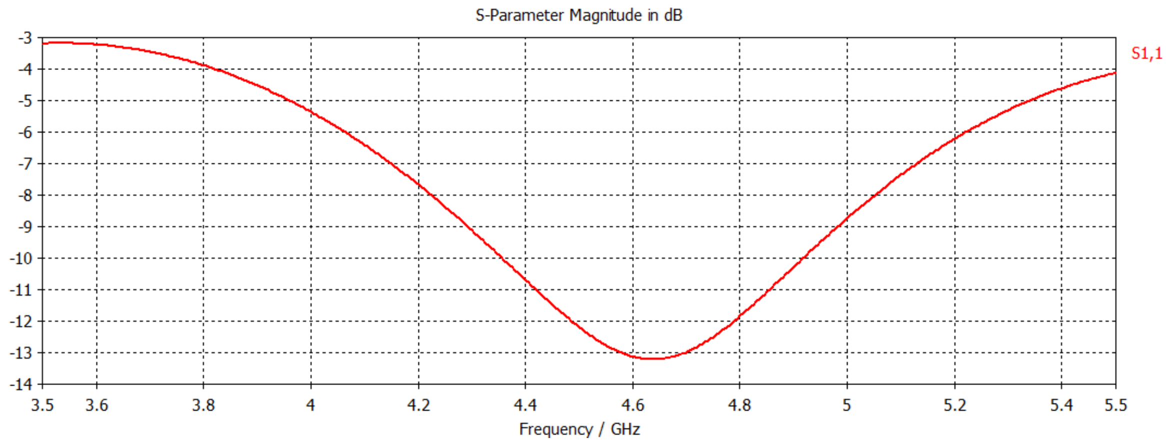
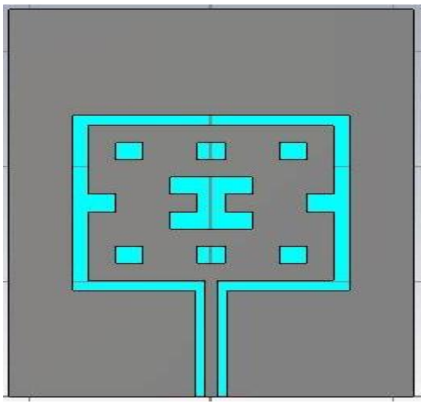


Figure 5.5: Return loss plot for Sierpinski carpet Antenna

Design VI



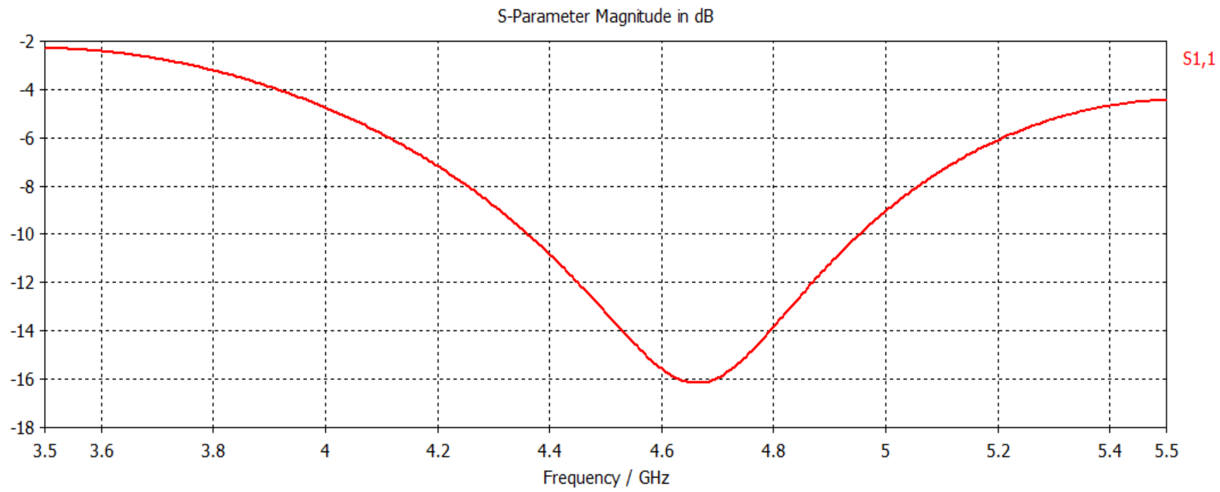
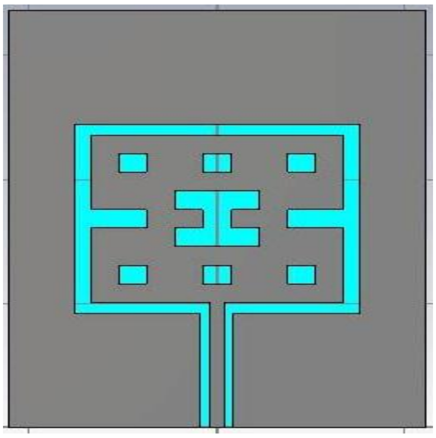


Figure 5.6: Return loss for Sierpinski carpet Antenna

Design VII



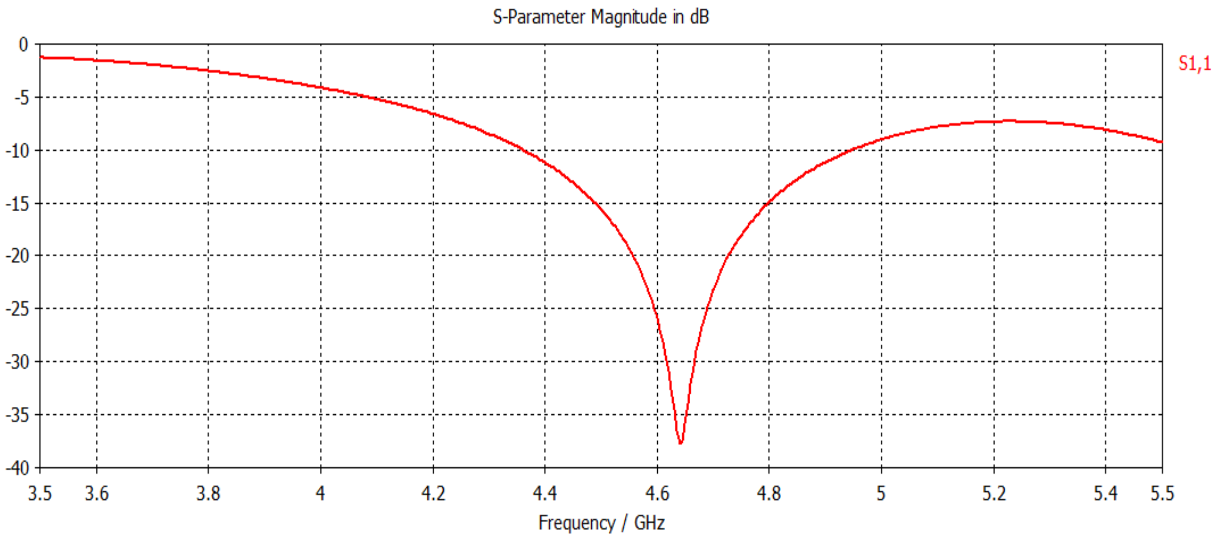
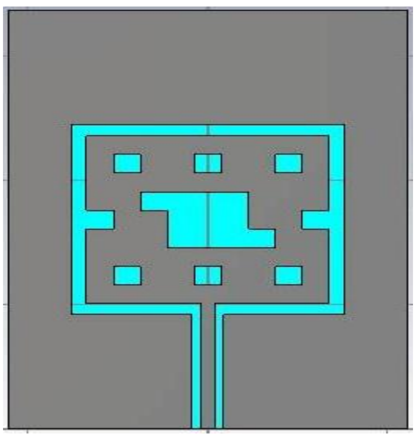


Figure 5.7: Return loss plot for Sierpinski carpet Antenna

Design VIII



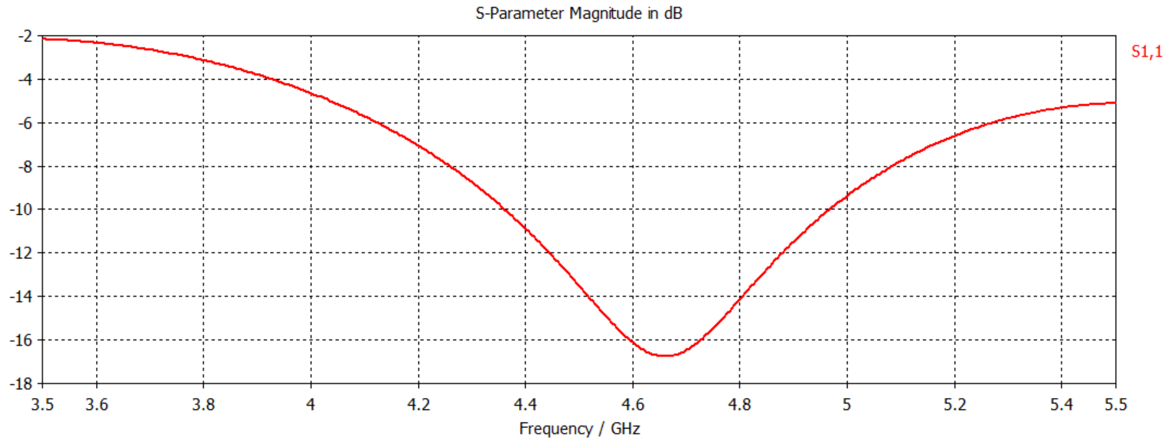
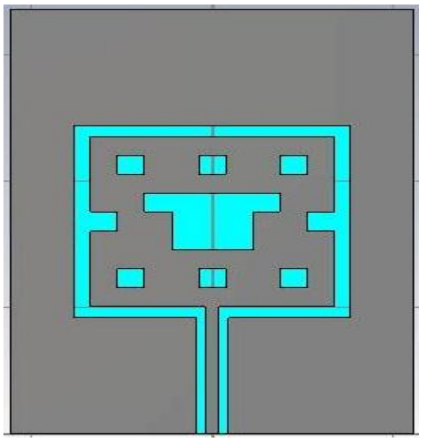


Figure 5.8: Return loss plot for Sierpinski carpet Antenna

Design IX



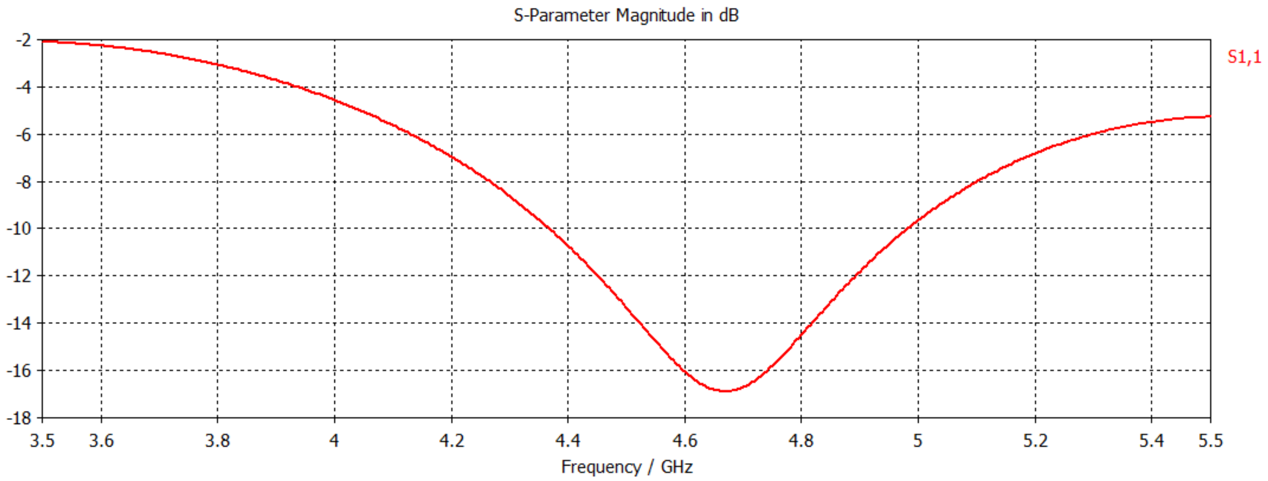
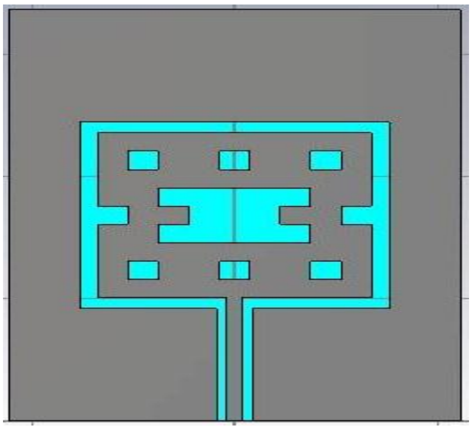


Figure 5.9: Return loss plot for Sierpinski carpet Antenna

Design X



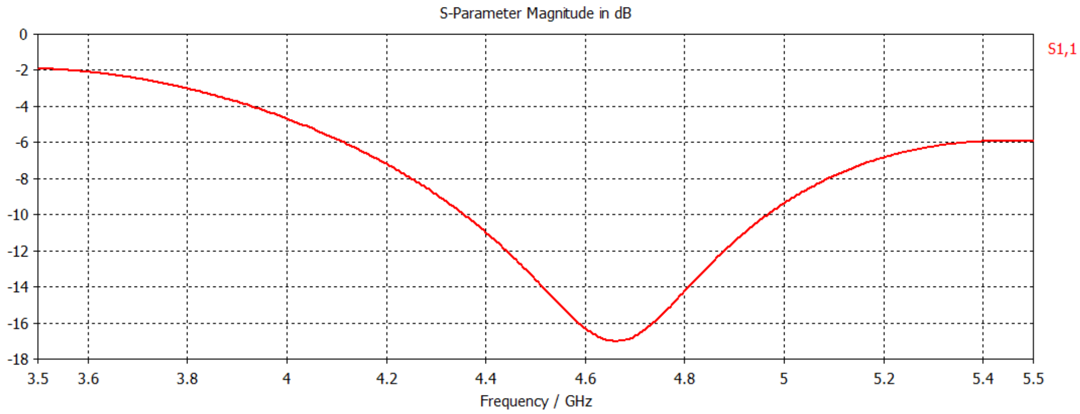


Figure 5.10: Return loss plot for Sierpinski carpet Antenna

Design XI

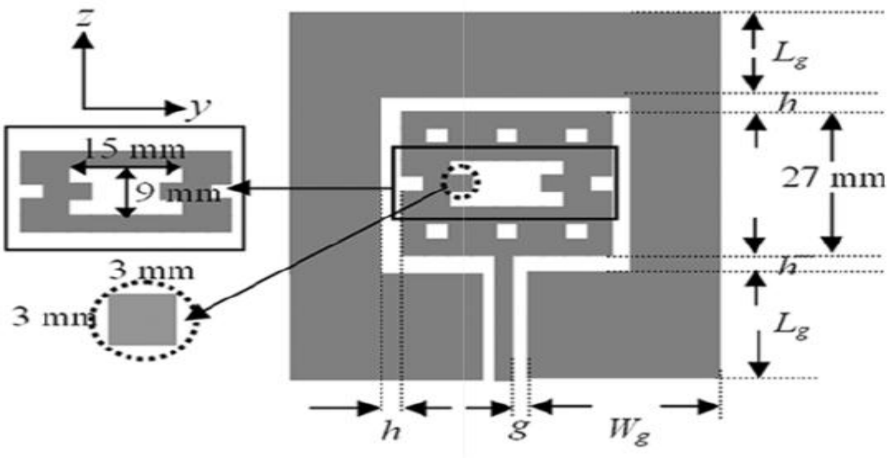


Figure 5.11: Geometry of Sierpinski Carpet Antenna

Parameter	Values
Thickness	1.59 mm
Permittivity	3.2
Central strip	20.5 mm
Length	18.4 mm
Height	1.743 mm

Table 5.1: Dimensions for Sierpinski Carpet Antenna Model

The above model provided with the dimensions was designed using CST Microwave Studio.

The views from different angles are depicted below.

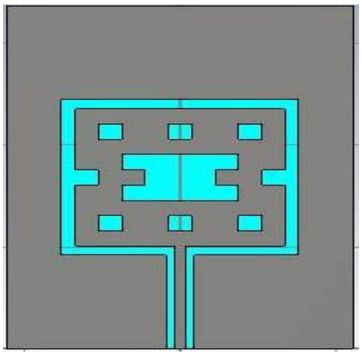


Figure 5.12(a): Front View

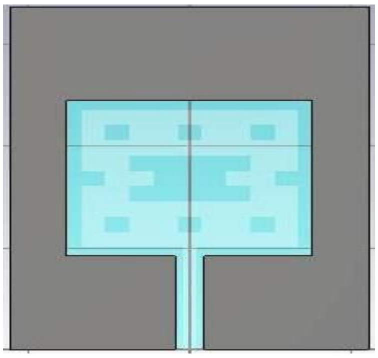


Figure 5.12(b): Ground Plane

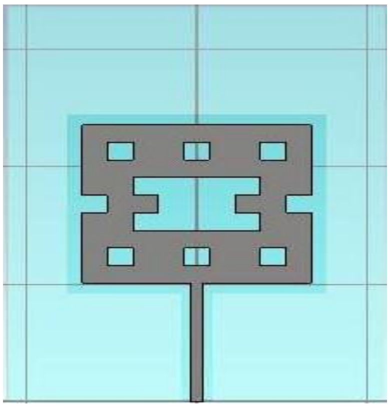


Figure 5.12(c): Radiating Patch with Feed Line

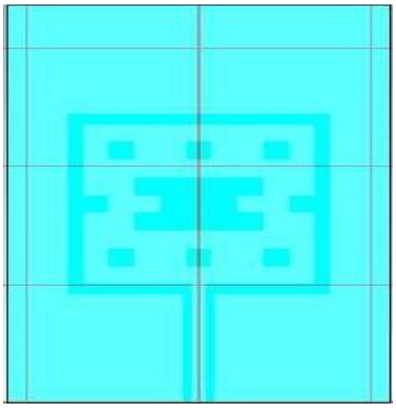


Figure 5.12(d): Substrate (Backside View)

The various parts of the Koch antenna were modeled and the respective materials were chosen. Permittivity of the substrate was taken as 4.4. All the parts were connected to a common port. Then the desired frequency of operation was chosen. After that the model was simulated to find the return loss. Following the return loss the Smith chart was plotted. Then the far field patterns at various frequencies were obtained using the CST tools. From those farfield values the gain was calculated.

Return Loss

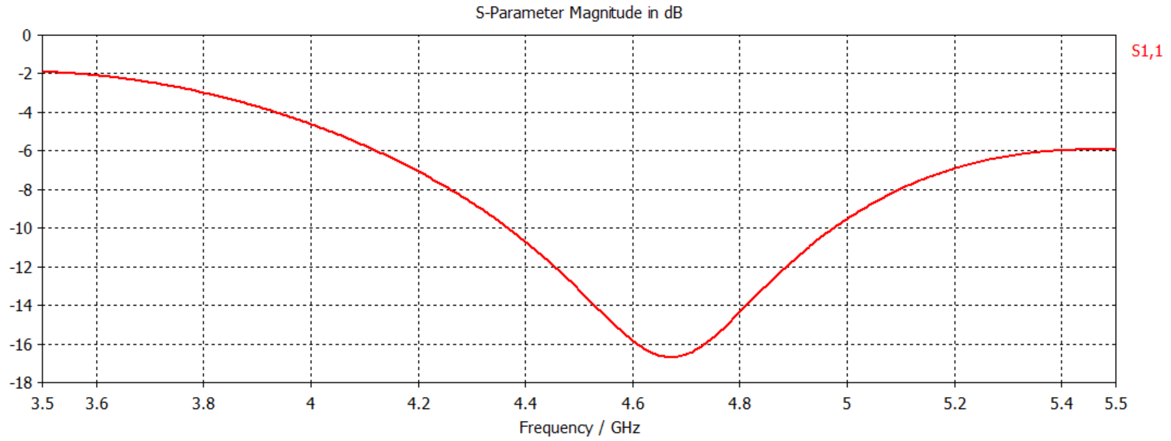


Figure 5.13: Return Loss plot for Carpet Antenna

Smith Chart

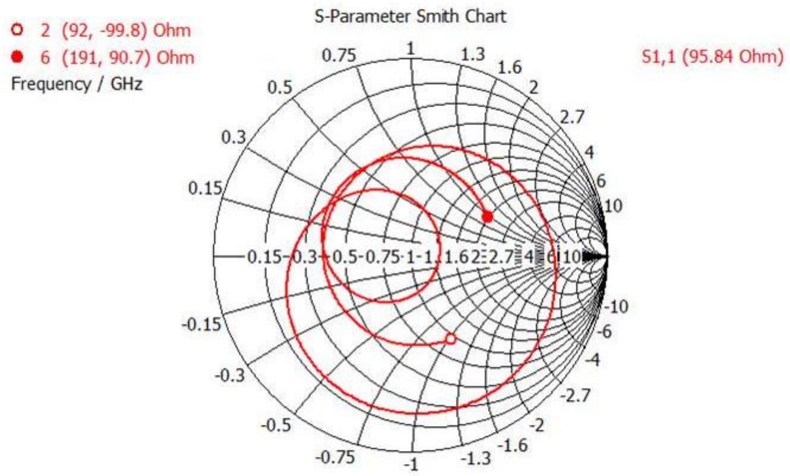


Figure 5.14: Smith Chart for Carpet Antenna

Far field Plot at peak (f = 4.5 GHz)

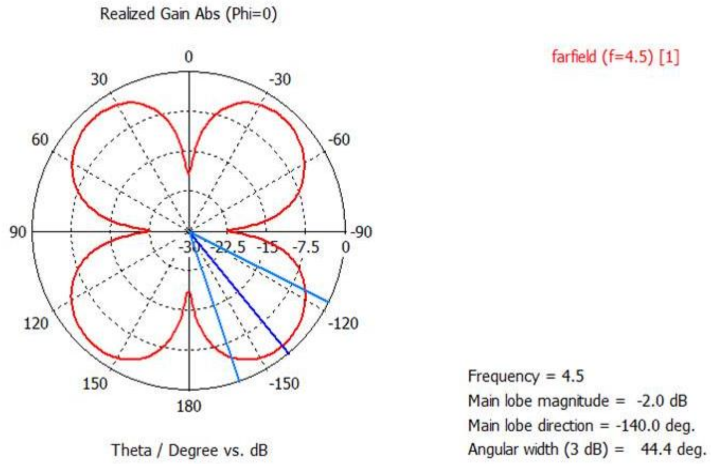


Figure 5.15(a): Polar plot for Carpet Antenna

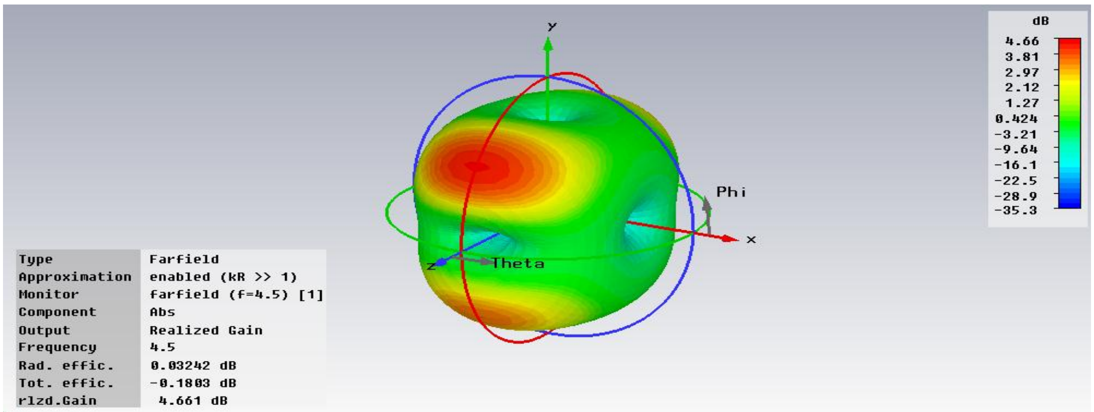


Figure 5.15(b): 3d plot for Carpet Antenna

Gain plot for Carpet Antenna

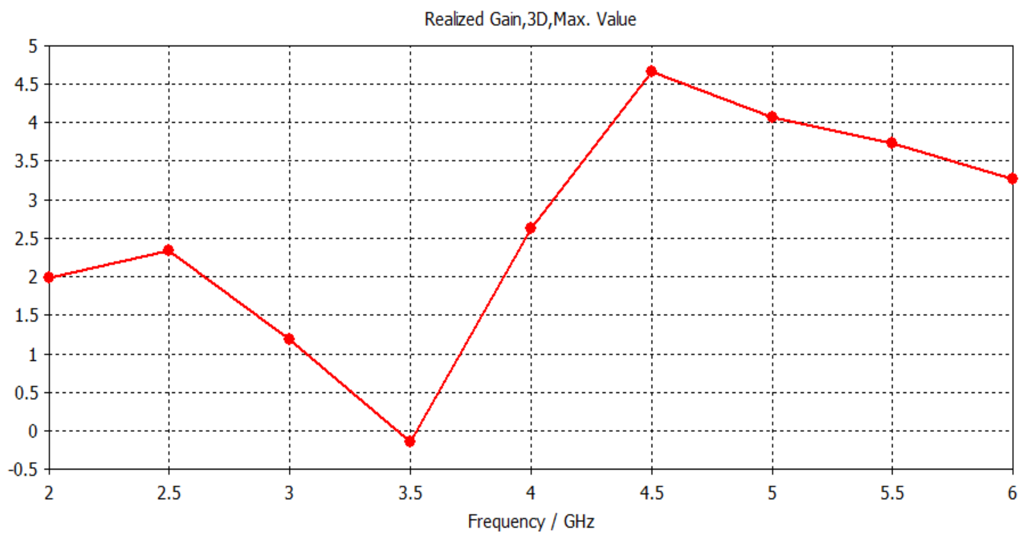


Figure 5.16: Gain plot for Carpet Antenna

CHAPTER 6

CONCLUSION AND FUTURE WORK

CONCLUSION

- CPW-fed Koch fractal printed slot antenna is suitable for WLAN 2.4/5.2/5.5 GHz and WiMAX 2.5/3.5/5.5 GHz operations. This geometry lowers the frequency of operation along with wide band matching and antenna size is compact as well as simple.
- Perturbed Sierpinski carpet fractal antenna with CPW feed is suitable for WLAN applications. The overall size can be effectively utilized for integrating with other components in WLAN communication devices.

FUTURE WORK

- The proposed antenna will be fabricated and measured result will be compared with simulated results.
- After fabrication it will be operated in the given conditions and the radiation pattern will be analyzed.
- The errors will be minimized by using given tools.

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